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recreation CARRYING CAPACITY

RECREATION CARRYING CAPACITY

This paper presents an approach for determining recreation carrying capacity of specific sites or areas. The material presented here was obtained from the papers cited in the Appendix and supplemented by field experience from many National Forest administrators.

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INTRODUCTION

Recreation use of the National Forests has been increasing steadily and the trend is expected to continue for most activities. Managers have been understandably reluctant in some cases to plan additional recreation facilities, to redesign existing facilities, or to take positive steps to regulate use "until the recreation carrying capacity can be determined."

In response to the concern of land managers, much research has been done on the carrying capacity question. It has proven to be a very complex problem. No cookbook recipes for determining recreational carrying capacity have been devised, and it is impossible to develop a precise measure of carrying capacity for most forms of outdoor recreation use.

It is the purpose of this paper to present briefly the basic concepts and principles related to outdoor recreation carrying capacity as advanced by several researchers, to discuss carrying capacity management techniques and carrying capacity considerations by activities, and to suggest a way to make carrying capacity estimates.

CARRYING CAPACITY CONCEPT AND PRINCIPLES

Nearly every writer on the subject defines carrying capacity in a slightly different way based on his particular orientation. As defined by Lime and Stankey (1971), recreational carrying capacity is the "character of use that can be supported over a specified time by an area developed at a certain level without causing excessive damage to either the physical environment or experience of the visitor."

They further observe that the goal of recreation management is to "maximize user satisfaction consistent with certain administrative, budgetary and resource constraints," and that recreational carrying capacity is "a multi-dimensional and dynamic concept" that can be manipulated by the manager within the framework of these same constraints. Following is a discussion of the several components of recreational carrying capacity.

Management Objectives

Carrying capacity can be evaluated only within the context of management objectives which specify the kind of recreational opportunities the area is to provide. Carrying capacity is not a fixed, absolute value inherent in every area. If management objectives for an area change, the carrying capacity will change also (Lime and Stankey, 1971; Wagar, 1964).

Recreational carrying capacity needs to be considered both in terms of the physical capacity of the site (biological or environmental factors) and by sociological factors affecting the pleasure of the visitor.

Physical Carrying Capacity

Recreation use has several effects on the physical resource. Trampling compacts soil and bruises and crushes ground vegetation, and root growth and tree stability are impaired. Some lost vegetation is replaced by more resistant species; some is not replaced. Changes take place which affect hydrologic characteristics, such as reduced available soil moisture, loss of plant litter, and increased chance of soil erosion. Water quality can be reduced due to discharges of oil and gas, and human waste can contaminate surface waters (Lime and Stankey, 1971).

Any activity within an ecosystem will alter it in some way. Such alteration is not necessarily undesirable, but recreation use beyond a certain level can destroy the desirable environmental characteristics of an area. The amount of change that is acceptable for a given area relates to and is determined by the management objectives for that area (Krutilla ____; Lime and Stankey, 1971). Thus the physical recreational carrying capacity of an area is that amount and character of use beyond which the physical resource will be unacceptably altered.

Sociological Carrying Capacity

The sociological component of carrying capacity relates to the effect of such factors as overcrowding and the condition of the physical resource on user satisfaction. In other words, sociological considerations are related to the effects of people on one another and the effects of the physical resource on people.

The sociological recreational carrying capacity is the measure of recreation productivity of an area in terms of user satisfaction. It can be defined as that amount and character of use beyond which aggregate user satisfaction is reduced to an unacceptable level.

Design Capacity

Another facet of carrying capacity is that it may be limited by space or mechanical constraints which are imposed by site or facility design. These constraints include such things as ski lift loading rates, parking lot or boat ramp capacity, and access and topographic limitations, all of which in some situations can restrict use to levels below physical or sociological carrying capacities. For example, there might be so few boat ramps on a large lake that it would be

impossible to launch enough boats in a day to exceed either the sociological or biological carrying capacity of the lake itself. The presence of excessively long waiting lines to launch would tend to reduce user satisfaction, so in effect the point at which that occurred would be the sociological carrying capacity of the boat ramps.

Time

One other important element of carrying capacity is that of time. Carrying capacity must be considered within a time frame to be meaningful, and carrying capacity will vary according to the time period in which it is expressed. Take, for example, a developed recreation occupancy site, such as a campground. Its sociological carrying capacity for any one point in time will be the number of persons who can use the site without reducing user satisfaction. This can be termed PAOT (persons at one time) sociological carrying capacity. Depending on the physical durability of the site, motives of the users, site design, and perhaps other factors, the PAOT sociological carrying capacity may or may not exceed the PAOT physical carrying capacity of the site. If the level of use at which visitor satisfaction is excessively diminished is reached before unacceptable physical damage occurs, the sociological carrying capacity is controlling.

Some activities, such as swimming, picnicking, and sightseeing, have a turnover rate greater than one. That is, because of the relatively short duration of visit, several parties normally use the same area during a day. The daily carrying capacity for these activities will be different than the PAOT capacity. For activities of longer duration, such as camping, daily and PAOT capacity will be the same.

Seasonal carrying capacity will be a still different figure and perhaps a different component will be controlling. Length of use season, and consequently the period available for site recovery, may significantly influence the amount of use that is acceptable seasonally. If the accumulative impact from use at or below the sociological carrying capacity level results in unacceptable physical change, the physical capacity is the controlling component.

ESTABLISHING MANAGEMENT OBJECTIVES

Proper consideration of sociological factors when setting management objectives requires an understanding of user attitudes and desires. Hendee and Pyle (1971) pointed out that managers may not always be good forecasters of such sociological phenomena as user preference and attitudes. They suggest that this is due to professional bias,

overexposure to outspoken special interest groups, and selective perception ("people see what they look for and observe what they expect to see"). If the manager recognizes that his perspective could be affected by these factors, and is careful to analyze and evaluate the derivation of his assumptions relative to user preference, his predictions can be improved.

The purpose of recreation management is to provide for user satisfaction, which necessitates having a concern for user preference. Some recreation activities are incompatible with one another. To avoid the futility of attempting to satisfy everyone and the ineffectiveness of managing for the "average user," it is important when establishing management objectives that the manager decide what segment of the recreation demand to satisfy in a given site or area, and then manage accordingly. When evaluating user opinion it is difficult to decide whom to listen to. In classified areas management options are limited, and the manager need only respond to demands that are consistent with the specified objectives of the area. However, outside of classified areas the manager has many options, and it is not as easy to determine which "public" to heed.

As stated previously, carrying capacity will differ with differing management objectives. As part of the analysis leading to establishing management objectives, questions such as these should be asked and answered:

1. What are the recreationsists who use this area seeking?

2. Are there conflicts between users engaging in incompatible activities, and if so, how serious are the conflicts?

3. To what extent can or should some of the public needs be met elsewhere (other National Forest lands, or other ownerships within or outside of the area)?

4. What are the cost benefit implications of the various management alternatives?

It is while asking and seeking the answers to such questions that the subject of "quality" must be considered. This in turn leads to the question of what constitutes quality. Managers sometimes use the word "quality" when they mean luxury or comfort. To these people paved parking spurs and electrical, water, and sewage hookups are evidences of quality. There are others who feel just as strongly that quality in outdoor recreation is only found where there is solitude and an absence of manmade facilities.

On the other hand, there are some broad quality standards that are agreed upon by nearly everyone. For example, most would agree that sand makes a better swimming beach than rock or mud, or that hunting and fishing areas have to "provide some minimum level of success" in order to receive any use (Clawson and Knetsch, 1966). One measure of quality is the degree to which site or area development and/or management is consistent with the management objectives that specify the desired experience level. For example, a rough plank table and stone fireplace per family unit would be an overimprovement at a Wilderness campground, and an underimprovement at a modern highway oriented campground. In both cases the facilities would be inconsistent with the quality goals as set forth in the management objectives.

The recreation experience level to be provided is closely related to the role of the area. The role of each area must be determined by analysis of public desires and needs, area suitability, and an understanding of the relationship of that area to the broader area. The Forest Service role in relation to that of other public agencies should be considered to ensure they are complementary and that public needs are satisfied without undue duplication or overlap. This could best be accomplished through interagency regional planning. Once this has been done and the decision has been made, the manager should not be too concerned by criticism from those who want a different kind of experience than is provided for. "By analogy, a Chinese restaurant would do well to ignore the opinion about food expressed by someone who ate there by mistake while seeking an Italian restaurant" (Lucas, 1970).

MANAGING FOR CARRYING CAPACITY[1/]

When the recreation manager determines (from physical or sociological indicators) that recreation use is approaching carrying capacity, he has two basic alternatives. Either the carrying capacity must be increased so that more use can be accommodated, or management measures must be taken to regulate the amount or pattern of use.[2/] Although things can often be done to increase carrying capacity, there is a limit to the amount of use that is acceptable under any given management objectives. When this limit is reached, some controls on use will become necessary. Use is regulated to limit the number of people who use an area and/or to achieve a more favorable distribution of use for the purpose of protecting the physical resource or of maintaining visitor satisfaction. Some of the techniques that can be employed to increase carrying capacity or regulate use are discussed under the broad categories of site design and management and management of people.

[1/] The primary references for this section are papers by Wagar (1964, 1966, and 1968) and Lime and Stankey (1971). Other references are cited as used.

[2/] There is a third alternative, which is to let use continue unabated and revise management objectives to reduce quality goals or alter the experience level to be provided, but for the purpose of this discussion that will be considered an unacceptable alternative.

Site Design and Management

There are numerous subtle design and management techniques that can be used to increase carrying capacity. One-way roads, paths, and trails can be designated to reduce encounters. Vehicle and pedestrian traffic can often be controlled through design and the use of natural barriers. Topography and vegetation (natural and planted) can be used to provide screening.

Often less subtle management measures are required. Artificial barriers might be needed to exclude traffic from sensitive areas, or concentrated use areas might have to be hardened with gravel or asphalt. Though an expensive alternative, sites can be redesigned and administered for day use. This may not permit an increase in total visitor days use, but due to shortened length of stay the area will be capable of serving more people. It does, of course, change the type of opportunity provided and the type of people being served.

Vegetative management, to increase the durability or aid recovery of the physical resource, can also be used to enhance carrying capacity. In some recreation sites partial removal of the overstory could enhance the growth and ability of understory plants to resist use while still providing sufficient shade and attractiveness for recreationists. It has been found that irrigation, fertilization, and seeding will accelerate site recovery in some places. Conversion of natural vegetation to species more resistant to trampling is another possibility in some recreation sites.

Some activities are regulated to an extent by the facilities necessary to engage in those activities. Ski lift and boat ramp capacity imposes use limitations. Use can be controlled in some sites by limiting the number of parking spaces.

Barriers of effort, distance, and time can be purposely designed into areas to restrict both the amount and kind of use (Wagar, 1968). Roads and trails may be foregone, or existing low standard roads and trails may be retained. Many people will not drive their vehicles on rough roads. Existing trails that are impassable for trail bikes or even horses because of such things as rock slides, rock terraces, or bog holes, may be left as is. Because of the time and effort involved, some people will not use areas that are accessible only by foot trail. If trails are excluded, some users who lack the confidence or stamina to travel cross-country will be excluded.

Limiting degree of access and mode of travel, by design or administration, can be employed to increase the effective size of an area and, consequently, the quality of the experience it can

provide for certain recreation activities. Paul Brooks summed it up this way: ". . . the size of a park is directly related to the manner in which you use it. If you are in a canoe traveling at three miles an hour, the lake on which you are paddling is ten times as long and ten times as broad as it is to the man in a speedboat going thirty . . . . Every road that replaces a footpath, every outboard motor than replaces a canoe paddle, shrinks the area of a park" (1970).

Management of People

User management has two primary objectives: to reduce depreciative behavior, and to increase the opportunities for visitor enjoyment.

In the long run, the indirect approach of attempting to modify visitor behavior by means of information, education, and persuasion might be the most effective. One premise of the indirect approach is that information and interpretation will result in increased awareness of and appreciation for the environment, thus enriching recreationists' experience and reducing their destructiveness.

Campaigns to make depreciative behavior socially unacceptable offer much promise. Hopefully, Woodsy Owl and Johnny Horizon will be as successful in preserving the environment and stopping pollution as Smokey Bear has been in reducing man-caused fires.

Illustrated talks, movies, slides, guided and self-guided nature walks and automobile tours, museums, brochures, maps, and guidebooks all offer opportunities to both increase visitor satisfaction and modify visitor behavior.

Campbell (1970) suggested that most depreciative acts are not done maliciously but rather in a spirit of fun, or through ignorance, or as a result of conflicts between managers' objectives and users' objectives. He proposed that the following management measures should help reduce antisocial behavior:

> Keep recreation areas clean and well maintained, as clean sites are littered less.
>
> Avoid rules other than those absolutely necessary and coordinate those rules with other agencies who administer public outdoor recreation areas.
>
> Provide for more contact between the managers and the users, both to learn the public's attitudes and to attempt to influence public behavior toward the recreation resource and facilities.

Some of the more direct approaches of managing people are discussed in the following paragraphs.

Zoning can be used to separate incompatible activities, thereby increasing visitor satisfaction. Zoning should be viewed in an overall regional context, whereby the relationship of the zoned area to the surrounding area is considered. By considering a broad area when zoning, planners can insure that a full range of recreation opportunities are available in the overall area. Lucas (1964) observed that other things being equal "the types of recreation with the fewest alternative locational possibilities should have priority for the use of the particular area." Zoning can help accomplish this.

Some activities or user groups which often compete for the same space and which are potentially conflicting are water-skiing with fishing; hikers, horsemen, and motorcyclists with one another (on the trail and in camp); and snowmobilers with snowshoers and cross-country skiers.

Zoning can be used to separate activities in either space or time. Water-skiing and fishing are classic examples. A lake might be zoned to exclude water-skiers in favor of fishermen, or it might be zoned to permit water-skiing from midmorning to midafternoon, the best time for water-skiing and generally the poorest time for fishing (Wagar, 1966). In the second example, neither activity is totally excluded from the area, but the conflict between incompatible activities is reduced. Without zoning, the most aggressive forms of use prevail at the expense of those activities which are the least crowd tolerant (Wagar, 1964).

Although most outdoor recreational activities are engaged in during a limited range of weather conditions and are, therefore, seasonal, there might be opportunities to discourage use during seasonal peaks and encourage early and late use.

Limits can be imposed on party size, length of stay, and mode of travel. For some forms of recreation this can serve not only to reduce use, but to lower the amount of physical and sociological impact per visitor day. Large parties tend to have a greater impact on a site than do several smaller parties. Large parties also have an adverse effect on other users. The physical impact from use can be related to duration of visit, especially in natural sites. Frequent changes in groups might afford some opportunity for site recovery because different groups use sites in different ways, and there is less chance that semipermanent "wickiups" and convenience fixtures will be erected. Restricting mode of travel might not only serve to reduce use, but it could reduce both the impact on the environment and conflict between users.

Use might be controlled and distributed to some extent by pricing. By charging differential fees, use might be discouraged in heavily used areas and favored in lightly used areas.

User testing and certification as prerequisites to engage in specific recreation activities is another way of regulating use. To date, this approach has only been used in the interest of public safety and to reduce the need for dangerous and expensive rescue efforts. Examples of present applications are the hunter safety programs conducted by State fish and game agencies, and the National Park Service practice of requiring mountain climbers to demonstrate adequate skill and equipment before they can climb in the Parks. Proficiency examinations might be one method of regulating use of National Forest Wildernesses or Back Country, or of activities such as white water boating, snowmobiling, and ski touring.

Lotteries would provide an important way of selecting users in situations where demand far exceeds carrying capacity. This would be equivalent to the present method of drawings for limited hunt permits. Reservations are being used in some places to regulate use. Some Oregon State parks have been put on a reservation system for the primary purpose of reducing the number of turnaways. A secondary effect is that local residents have the advantage in these parks since they are better able to call in advance for reservations. Nonresidents continue to monopolize those parks not under the reservations system.

CARRYING CAPACITY CONSIDERATIONS BY ACTIVITIES

Space standards have been developed by various agencies for some recreation activities. Some of these standards are referred to in the following activity discussions; they as well as others are summarized in the USDI-BOR publication, "Outdoor Recreation Space Standards" (1967). Space standards should be considered in their proper perspective. They reflect the management objectives of the agency that developed them, even though the management objectives might be very informal. Most standards do not represent an expression of carrying capacity, however. Those that do probably just relate to the social aspects of carrying capacity and specify the space needed to avoid overcrowding.

Space standards might provide some useful guidelines if their limitations are recognized and their origins are known. Those that were developed by a municipality would probably be of little value to the Forest Service except for Forest Service recreation areas adjacent to metropolitan areas. Space standards developed by an agency with objectives similar to those of the Forest Service might warrant some consideration.

In the following discussion carrying capacity and possible management measures related to carrying capacity will be considered for some of the more important National Forest recreation activities.

Boating

Fast water boating, which includes boating, kayaking, and rafting, is growing rapidly in popularity. These activities are limited by available suitable water. The accessibility of boating streams influences use, and availability of streamside campsites can affect the capacity of streams that require more than one day to run. Other factors influencing capacity are stream size and speed, number and spacing of portages, and the mix of user skills and craft types. There is some possibility of conflict between canoes and kayaks and rubber rafts, which are slower. Conflicts can result between the novice and those more skilled. Fast water boating might also conflict with stream fishing.

Zoning to separate different type craft, by either time or location, is one management option to reduce conflicts. Classifying streams according to degree of difficulty, and posting and otherwise publicizing these classifications could be employed to inform prospective users and discourage unqualified people. Brochures outlining safe white water boating procedures and explaining stream classification could be useful management tools. Zoning could be employed to reduce conflicts between boating and fishing in some streams with high fishing values.

Stillwater boating activities include rowing and paddling, water-skiing, motorized cruising, sailing, and fishing, both by trolling and at anchor. The detrimental physical effects usually associated with boat overuse include reduced water quality due to gas and oil discharges or bottom disturbance and shoreline erosion due to wave action from boat wakes.

Water-skiing is probably the most aggressive type of boating activity; water-skiing conflicts to an extent with most water related activities, but especially with fishing and swimming. Just a few sailboats can have a large effect on other boating activities, especially on small lakes. This is because the rules of the road for boats give boats under sail the right-of-way over boats under power.

Many factors influence the space required for various forms of boating. Size is a major determinant of a lake's efficiency for boating. Large lakes normally have more water surface per unit of shoreline, and are consequently able to accommodate relatively more boating without conflict. Shape also affects lake efficiency for boating. Acoustics can be an important determinant of carrying

capacity in some situations. High noise levels can occur from boat motors in the natural amphitheaters of many mountain lake basins. The location of boat ramps, marinas, swimming sites, and the traffic and use patterns that result from these and other shoreline developments have a major effect on the boating carrying capacity. The mix of boating activities is an important determinant of boating capacity by activity. Space needs for any given boating activity will be less per boat if it is the only activity on a lake or portion of a lake.

The space standards published by BOR reflect a wide variation between agencies for most forms of boating. For instance, the standards for water-skiing specify the need for from 1 to 40 acres per boat. The requirement for fishing from anchored boats ranges from 4 to 20 boats per acre, and for trolling boats the range is from 2 boats per acre to 8 acres per boat. These variations could be reflections of vastly different management objectives; more likely they simply reflect differences in opinion as to what the space needs are for these boating activities.

Boating space standards all appear to be related to the space required to avoid overcrowding and conflicts. The literature contains very little about determining the physical carrying capacity for boats. Stewart and Howard (1968) refer to studies which relate seasonal outboard motor fuel usage levels to the effect on water quality. These studies indicate that if approximately 1 gallon of outboard motor fuel is consumed per million gallons of lake water per season, there is an increase in the threshold odor number of the water; most people consider a threshold odor number of 3 to be objectionable. The studies also found that at fuel consumption levels of 8 gallons per million gallons of water, fish flesh is tainted. One million gallons is roughly 3 acre-feet. Equating observed motorboat usage to outboard motor fuel consumption would be difficult for most lakes, and there are numerous factors that could influence the water quality from gas and oil discharges. Some of these factors are water temperature, amount of aquatic plant life, chemical composition of the water, and the mixing characteristics of the lake (seasonal turnover, degree of lateral flow, and replacement rate from inflow and outflow).

Roiling of the bottom through propeller turbulence and bank erosion from boat wakes are other possible physical impacts from motorboating. Bottom disturbance is a factor only in very shallow water, as the mixing caused by propellers does not extend very deep. Bank washing is most serious on small lakes and in restricted channels, especially where shorelines are steep and/or composed of unstable soils.

Some management measures that can be taken to regulate boat use are zoning (in time or space), limiting launch sites and activities, controlling boat and/or motor size, imposing speed limits or no-wake

rules, prohibiting motors, and establishing one-way traffic flow. The States control most of the surface waters on the National Forests, and most of the above measures would have to be initiated by the appropriate State agency. The Forest Service can control the character of boat use on waters completely surrounded by National Forest land by the amount and type of access it provides. Ramp design and capacity impose a real mechanical constraint on the number and size of trailered boats that can use a lake, especially in day use situations.

Ashton and Chubb (1971) suggested a method which can be used both to count boat use and to determine conflicts between boaters and between boats and other water-oriented activities. Their approach was designed to be applied statistically in combination with questionnaires to estimate boating carrying capacity based on boater satisfaction. They measured boat dispersion and use levels by taking high oblique photographs with a handheld camera from a small aircraft. They took a series of overlapping photographs at hourly intervals while flying a predetermined route around the lake. The overlapping photographs provided a record of boat movement which allowed them to plot potential conflicts. Even without statistical analysis, a series of such photographs taken at intervals during randomly selected peak use days would be a valuable tool for recreation planning of water areas. Plotted on overlays by time period, the data would provide the planner with an insight into traffic patterns, use concentration, and conflicts that would otherwise be difficult to obtain by surface observation.

Over-Snow Travel

This group includes all winter travel on trails, unplowed roads, or cross-country.

Some of the factors that affect snowmobiling capacity are availability of either gentle open terrain or suitable unplowed roads or trails, plowed parking facilities, areas of wildlife concentration, and delicate ecological areas. Snowmobilers as a group appear to be tolerant of one another and of other types of users. The size of plowed parking facilities can impose limits on the number of machines that can satisfactorily operate from some areas. Traffic congestion and other management problems will result from inadequate parking facilities.

One-way loop trails would reduce conflicts between snowmobile groups and increase the number of machines that could safely use an area. Although inconclusive, some research indicates possible detrimental

effects to ground vegetation and small mammals due to compaction of the snow. Soil temperatures were found in one study to be lowered due to snowmobile compaction in snow depths up to 20 inches.

Areas with tree reproduction should be closed to snowmobiles at least during periods when snow cover is less than a foot or two over the tops of the young trees--possibly such areas should be closed season-long until the trees are several feet above maximum snow level.

It will probably be many years before the popularity of cross-country skiing and snowshoeing will increase to the point that carrying capacity will be of concern. Parking facilities at popular takeoff points could exert controls in some places.

Although snowshoers and cross-country skiers often take advantage of packed snowmobile tracks, studies have indicated a strong intolerance among these people to encounters with snowmobiles; at least part of this conflict stems from snowmobile noise. Snowmobilers, on the other hand, do not mind encountering skiers and snowshoers, and possibly it even enhances their experience to see them. Separation of these conflicting activities by zoning should be considered in areas where there is a significant amount of both types of winter use. Since snowmobilers do not mind encountering nonmechanized travelers, the zoning could be one-sided; that is, some localities could be set aside for nonmechanized winter travel only, with the remaining area left open to all types of travel.

Off-Road Travel

The activities in this grouping include both trail and cross-country travel by means of foot, horse, trail bike, or 4-wheel drive vehicle. Parking facilities at takeoff points can be a limiting factor for all types of off-road travel with the exception of 4-wheel drive vehicles. Availability of campsites at takeoff points and along trails could influence carrying capacity in some situations.

The sociological carrying capacity will normally be the controlling component as far as trail oriented foot travel is concerned. Foot travel is generally the least destructive form of cross-country travel for any given situation. Noticeable physical impacts can occur from foot travel in alpine areas, wet ground, lightly vegetated steep slopes, and in other situations where soil or vegetation is fragile.

Horse travel causes relatively greater physical impact than does foot travel. Horses can also have a significant impact in and around campsites. Trees can be damaged by rubbing and root compaction if

stock is tied to them. Ground vegetation is quickly destroyed in hitching areas. The areas around many horse camps are overgrazed; in some areas where horses are used there is no suitable horse feed.

Hay packed in to feed horses results in wide distribution of undesirable plant species. Encounters with horse parties and the physical impacts from horse passage have been found to detrimentally affect the satisfaction of hikers. Some physical impacts from horses which diminish hiker satisfaction are manure and the flies it attracts, increased dustiness and hardness of trail surface, and larger and deeper muddy sections where trails cross wet ground.

Horses and mechanized vehicles are generally incompatible. Encounters between stock and trail scooters can be dangerous on some trails. Encounters can generally be avoided or are less serious in cross-country travel, which is generally undertaken in relatively open country. Thus, converging parties can usually see one another in time to either alter their routes or pick a safe spot to meet.

Trail scooters and 4-wheel drive vehicles, if used on properly located established tracks during dry periods, may not result in significant physical damage. The noise and dust caused by these vehicles causes them to be generally disliked by people engaged in more primitive forms of travel. There is also a psychological element which serves to reduce the experience level of the hiker or horseman when he encounters a motorized vehicle on the trail.

There are several management options for reducing the physical impact from off-road travel. They include such things as limiting travel to existing trails and designated routes, surfacing trails and bridging or draining wet spots, prohibiting grazing and tying of stock to live trees, providing corrals or hitchracks, prohibiting importing of hay and requiring use of pelletized feed. Measures that can be taken to reduce conflicts between different types of off-road travel consist primarily of one form or another of zoning. Some areas might be zoned to permit foot travel only, either to protect the physical resource or to reduce conflicts. Trails might be zoned to exclude mechanized travel. This has already been done on main access trails to classified Wildernesses, and on other trails with an established and significant horse use to reduce the hazards of encounters between stock and trail scooters. One other possibility for reducing the depreciative effects of off-road motorized vehicles is that of imposing decibel output limitations on such vehicles.

Camping and Picnicking

Traditionally, the capacity of developed Forest Service camp and picnic sites in terms of people at one time (PAOT) has been considered to be that which the site is designed to accommodate.

This is generally calculated as being 5 times the number of family units or parking spaces. A five-level development scale has been developed that provides density and environmental modification guidelines designed to afford various levels of recreation experiences (FSM 2331.11). These are, in effect, space and design standards that are based on broad Forest Service recreation management objectives.

Sites might not be able to accommodate sustained daily use at design capacity without suffering unacceptable physical damage. In such cases, one or more of the management techniques discussed previously must be applied to either increase capacity or limit use. Most measures taken to increase permissible use result in additional environmental modification. This in turn usually results in a different kind of recreational opportunity, and might attract a different clientele. If such a change is inconsistent with site management objectives, either the objectives must be changed or use must be regulated.

There are two general categories of Forest Service camp and picnic sites: (1) those that serve primarily as overnight or lunch stops, often located immediately adjacent to main travel routes; and (2) destination sites associated with some activity-oriented attraction, such as a lake. When considering the carrying capacity for destination type areas, much of the concern is related to the impact on the area served by developed sites, not just the effect on the sites. To deal with this question requires a knowledge of what people who camp or picnic at the developed sites do while off-site.

Most swimming sites in Region 1 are developed in conjunction with camp or picnic grounds. Most are used for sunbathing and water play near the shore; the combination of typical Region 1 water and air temperatures limits swimming to a relatively short season. In Region 1 swimming site carrying capacity is almost wholly related to the beach area, and it is limited by the sociological component (overcrowding).

Wilderness

Although classified Wildernesses were not established for, and are not managed as, recreation areas, nearly all wilderness use is recreation oriented. Wilderness management options are limited to those that are consistent with the policies, objectives, and management direction stated in the Wilderness Act.

Stankey (1971) wrote ". . . wilderness carrying capacity must be defined at least in part as the ability of an area to provide the visitor with a satisfactory experience over time." He said that

to determine this requires an understanding of what users consider to be excessive physical change as well as unacceptable amounts and kinds of use. Lucas (1964) observed that "An important and probably essential characteristic of a wilderness is limited use."

Researchers have discovered several things about wilderness users that can help managers establish wilderness recreational carrying capacity standards.

Wilderness purists (defined by Stankey, 1971, as persons whose perception of wilderness was the most consistent with the definition set forth by the Wilderness Act) typically thought of wilderness as a place to find solitude in undisturbed surroundings. Satisfaction for most begins to decline beyond about two encounters per day. Backpackers experienced reduced satisfaction if more than one horse party was encountered. Encounters with several small parties was preferred to meeting even one large party. Visitors apparently anticipated encounters near the perimeter of the Wilderness and therefore reacted less adversely to them. Encounters near camp were especially distasteful, and most users desired to camp out of sight or sound of others. Any litter or physical signs of wear were particularly disliked by all classes of visitors.

Most Wilderness use is concentrated along main travel routes and at attractions such as lakes, good fishing streams, and prime hunting areas. One of the challenges of carrying capacity management in Wilderness is to gain better dispersal of use.

There are numerous management techniques for regulating the amount and nature of use within Wilderness. Indirect controls are always preferable to direct controls. This is especially true in Wilderness, where direct regulation and manipulation of the user is apt to impair the intangible element of "the wilderness experience."

The indirect techniques for regulating use and user impacts fall mainly under the broad categories of education and persuasion and access manipulation. Prospective users can be directed away from heavily used areas and into lightly used areas by means of informational maps and brochures and by personal contact with Wilderness Rangers. Forest Service personnel can be assigned to contact organized wilderness trips where they can influence the wilderness philosophy and ethics of the participants.

Access manipulation includes such things as regulating the number, location, and capacity of jump-off facilities outside the Wilderness and the location, design, and maintenance of trails within the Wilderness.

Direct controls will have to be employed in some cases to protect wilderness values. Direct controls can be undertaken to regulate the amount or type of use to either prevent or halt resource damage

or reduce conflicts between users. By requiring users to obtain permits before entering the Wilderness, managers have the opportunity to influence what travel routes or campsites are used. A reservation system with a limited number of permits could be adopted in heavily used areas. Length of stay and party size limits can be imposed. Camps in heavily used travel corridors and at attractions can be closed, either permanently or on a rest rotation basis.

Stock use can be restricted in several ways. Stock can be prohibited in some areas, or limits can be placed on the maximum number per party or per person. Supplemental feed in the form of hay or pellets can be required. Some areas can be closed to any grazing. In some areas it might be necessary to restrict horse travel to trails or to limit horse use to certain parts of the season.

Zoning can be employed to reduce conflicts. This can take several forms. Some trails may be zoned for foot traffic only. One-way routes could be established to reduce encounters. Separate camp areas for horse and foot parties would be useful in some areas. Time zoning might be employed to reduce conflicts between horse and foot travelers.

Wilderness managers could work with fish and game agencies to adjust hunting and fishing seasons to help disperse use in some situations.

Skiing at Developed Ski Areas

Alpine skiing is one of the few outdoor recreation activities for which reasonably specific carrying capacity estimating procedures have been developed. Brandenberger's (1972) paper, which is the source for this section, should be referred to for a more complete discussion of ski area carrying capacity.

The number of skiers that can be accommodated at one time (SAOT) is the most useful measure of the capacity of a ski area. The SAOT capacity is equivalent to daily capacity for areas which operate only during the day.

A people at one time (PAOT) capacity may also be expressed for a ski area. It is the capacity in terms of SAOT plus any nonskiers and spectators. Since the percentage of nonskiers is usually low, SAOT is the more meaningful measure of capacity.

A primary objective for an alpine ski area is to maximize profits over an extended period of time. With increasing popularity of skiing some operators have started to limit the number of daily ticket sales

to avoid having the area gain a bad reputation of being overcrowded. These ski area managers are, in effect, seeking to limit skier numbers to the sociological capacity of their areas.

The sociological capacity of a ski area is determined partly by the clientele served and partly by the availability of substitute facilities. Skiers at areas near population centers are relatively much more tolerant of crowding than are vacationing powder skiers.

Adverse impact on the physical resource due to use is seldom a problem on ski areas, but the capacity of ski areas may be controlled in some cases by physical or ecological factors which limit development. Soil and watershed constraints and availability of water are examples of factors that can impose physical limitations on development.

Ski area capacity is related to the design capacity of the parking lot, lodge, ski lifts or tows, and ski slopes. These elements vary in importance, but all are potentially controlling. Following are some guidelines for calculating the capacity of these facilities.

Parking lots can accommodate about 145 cars per acre if parking is supervised, or 110 cars per acres if unsupervised. In order to assess existing skier capacity or space required when planning an area, bus, employee, and nonskier parking needs must be considered, and the number of skiers per car must be estimated.

Lodge capacity requirements vary widely according to the type and location of the ski area, and from day to day according to the weather. Five square feet per person is a general guideline for a day lodge and related facilities.

The capacity in number of skiers per operation can be calculated for each of the lifts in a ski area if these things are known: vertical rise in feet, hourly lift capacity, hours per operation, type of ski slopes served (novice, intermediate, or advanced), and type of clientele. It is possible to estimate lift capacity with this information because skiers generally ski a relatively constant number of vertical feet per day, depending on their ability level. The range is from about 7,000 vertical feet for low intermediates to about 10,000 vertical feet for advanced skiers; an overall average is about 8,000 vertical feet per day. The following formula is used:

$$\text{Skier Capacity Per Operation} = \frac{\text{Vertical in Feet} \times \text{Hourly Capacity} \times \text{Hours of Operation} \times .9}{\text{Vertical Feet Skied Per Person Per Day}}$$

The .9 is an adjustment for loading efficiency. The skier at one time capacity (SAOT) for the area is the sum of the skier capacity per operation for all lifts. Adjustments must be made for lifts used wholly or partially as access to other lifts.

Ski run capacity is a function of snow conditions, width of runs, skier ability level, and terrain characteristics. Slope steepness is the primary controlling element, however, as it relates directly to the suitability of a run to serve the various skier ability levels.

Skier at one time capacity of ski runs can be estimated using the following guidelines:

Skier Ability	Ski Run Slope Range	Desirable Percent of Ski Area	SAOT/Acre
Novice	10% to 20%	20%	35
Intermediate	20% to 40%	60%	15
Advanced	Over 40%	20%	5

Since most skiers are in the intermediate ability class, and since advanced and expert skiers spend much of their time skiing on intermediate class runs, a higher proportion of either novice or advanced runs contributes little to capacity.

ESTIMATING RECREATION CARRYING CAPACITY

No systems have been devised for objectively quantifying the carrying capacities for most outdoor recreation activities. Recreation is a subjective resource which does not readily lend itself to objective analysis. Recreation research efforts are directed at reducing this subjectiveness, and research is providing much information about both user attitudes and effect of recreation use on the physical resource of specific areas.

Research on recreation carrying capacity has been primarily directed to study of specific factors affecting carrying capacity. We urgently need a wide based research project aimed at developing a systems approach that will enable the land manager to determine the capacity of a specific unit of land. The system should be designed to provide answers on carrying capacity for a variety of management objectives. In the meantime managers will have to extrapolate from existing knowledge to arrive at the best answers possible. By using the following procedure it should be possible to make at least a "ball park" estimate of carrying capacity for any given site or area.

1. Determine area to be analyzed for carrying capacity. The area should be kept to a realistic manageable size, but it should be large enough to insure that use impacts on the overall area are not overlooked.

2. Develop management objectives. Because carrying capacity will vary as management objectives vary, the objectives must be set before carrying capacity estimates are attempted. To set management objectives

requires an understanding of the response of the physical resource to various levels of use and management and an understanding of user desires and attitudes. During this step it is tentatively decided what range of recreation activities the area should provide; this requires a knowledge of what opportunities are available outside the planning area. Quality goals, expressed in terms of acceptable change in the physical resource, acceptable site modification (hardening), and user density, are also set. Estimating carrying capacity must be done in conjunction with, not separate from, recreation composite planning.

3. Analyze current situation.

a. Physical condition of area. Compare use sites and use areas with adjacent unused areas of the same habitat type to determine the physical change that has resulted from past recreation use.

b. Gather use data. Assemble all available use data relative to the study area. Estimates are needed for both total seasonal use and peak season weekend day use.

c. Observe use. On several randomly selected, nonholiday, peak season weekend days, systematically observe the activity in the study area. Observe and record (1) visual impressions of user density as expressed by presence or lack of overcrowding, and (2) conflicts between activities or among those engaged in similar activities. Record impressions by activity and subarea (i.e., campground, swimming beach, boat launch, water surface by zones, etc.) for various time periods throughout the day. The same time schedule must be followed on each of the selected days.

d. Count use. Make actual counts by activity and subarea using the same time periods. If possible the aerial photographic technique discussed under the preceding boating activity writeup should be used to measure water use. Make ground counts where the aerial view is obstructed. Axle counts and preferably origin and destination studies should be made at all traffic meters.

4. Evaluate the data.

a. Physical considerations. Based on a comparison of adjacent areas of the same habitat type and a knowledge of the characteristics and management implications of the habitat types, estimate the percentage of current use in relation to that acceptable under area management objectives. In other words, compare the study area to nearby unused areas and decide whether or not the study area shows signs of unacceptable physical change. If so, estimate the extent of overuse; if not, estimate how much additional use could be supported. Apply this percentage to seasonal use data to determine estimated seasonal physical carrying capacity under the present level of management.

b. Sociological considerations. Based upon a subjectively assumed acceptable use density, evaluate the density and conflicts observed by activity. For each activity estimate the percentage relationship of observed use to acceptable use. Apply these percentages to actual counts by activity to determine estimated daily or PAOT carrying capacity for each activity.

The estimates derived in (a) and (b) will only be applicable for the current level of management and for the same level and character of use as when observed.

Experience and judgment are needed to make this approach work. The approach is untried, and should be viewed as an intermim process; it involves the application of much intuitive judgment, some of which may prove to be substantially wrong. It does, however, provide a systematic and orderly way of wrestling with a complex and urgent problem. The capacity figures that result should be used cautiously, monitored continuously, and adjusted as more knowledge is gained.

The importance of obtaining good use data cannot be overemphasized. Before managers can either estimate carrying capacity or manage within it they must have reliable use figures. To be of use as a management tool this data must be collected in a manner that is statistically sound. Unsystematic counts are of little value. Double sampling is a sound technique if applied properly, but alteration of the system in any way makes the data statistically meaningless. A major source of error in much recreation use sampling is length of stay bias; i.e., the probability that a visitor will be counted is directly proportional to his length of stay. Length of stay bias is especially significant for Wilderness and Back Country recreation use sampling. Lucas (1964a) found in one Wilderness that use estimates not corrected for length of stay bias were 3 times greater than corrected estimates.

Once the carrying capacity has been estimated for the existing level of management and use, various management alternatives can be developed to reduce or avoid undesirable physical impacts or conflicts between users. In doing this managers can employ any combination of the management techniques discussed in the preceding sections, as long as they are realizable within budgetary limitations and consistent with management objectives.

APPENDIX

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Other References

An annotated bibliography of literature related to recreational carrying capacity, containing nearly 200 references, will be published soon by the Intermountain Forest and Range Experiment Station, Ogden, Utah.